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Adaptive Visualization of Collaborative Status in Process-oriented Collaborative Learning

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Abstract: - Wiki is the powerful hypertext-based collaborative systems and the conversational knowledge management system. However, some factors interrupt the social interaction needed for collaboration in wiki. At first the linked-structure is hidden and continuously changeable. Furthermore, the linked structure has become more and more complex. The linked structure's complexity interrupts collaborative condition monitoring and group collaboration. We develop and test new adaptive measures proposed in this paper to decide whether or not they satisfy a group's collaborative condition. The visualization of these scores will support a basis to examine the collaborative status and to decide the starting point of next activity in process-oriented learning. The simulation's result shows that changes in score values go with collaborative status.

Key-Words: - Collaborative Learning, Knowledge Management, Visualization

1 Introduction

Socio-constructivism is the approach in which interpersonal knowledge can be achieved only by its social construction. In collaborative learning, collaboration is a key element for social construction [4]. And active social interactions are also an important factor for learning's effectiveness in virtual collaborative learning environments [9]. Social interactions could be achieved with various communication tools to support knowledge management such as wiki in virtual environments.

Knowledge Management is capturing, organizing and storing the knowledge and experiences of individual workers or groups within an organization. One knowledge acquisition method has developed using artificial intelligence and data mining. The knowledge acquisition effort is highly resource intensive [10]. Artificial intelligence based knowledge acquisition thus faces considerable applicability constraints.

C. Wagner *et al*. proposed that wiki is an efficient conversational knowledge management system [12]. He defined collaborative knowledge management as a technology that supports conversational knowledge creation and sharing such as e-mail, video and audio streaming, static and DB backed web pages, discussion forum, internet chat/instant messaging, weblog, wiki, etc. [11]. He said that wiki is particularly interesting because of the paradigm shift in knowledge creation and sharing it requires. He also presented that this collaborative and conversational knowledge management system might remove the knowledge acquisition bottleneck.

Wiki has a powerful advantage as a collaborative learning system. In the previous article of H. Kim *et al*. he examined the effect of conversational knowledge management technology through a controlled group-based experiment in wiki. He examined wiki's subtle effect on the foreign language translation project [7]. He examined the pattern of modification

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frequency in the foreign language translation project, and he counted the frequency of events in which learners translated or modified sentences from the sentences translated by others. The frequency increased slowly as time passed. However the frequency suddenly decreased at any one point of high frequency. Team members' knowledge interacted heavily for agreement on translated terms and context. This experiment showed how differences in opinion were adjusted by the conversational knowledge management technology during translation.

The next experiment, a relay novel project, showed that learners' creative imagination was facilitated by virtue of the conversational knowledge management technology [8]. In wiki the authored novel used more vocabularies than the bulletin board-based system's novel. And we found that the range of imagination was enriched by the interactivity of conversational knowledge management technology. H.Kim examined the effectiveness quantitatively by a count of visual changes. The change shows the same pattern with the above experiment.

In spite of these advantages, H. Han found that the complexity of a linked structure could cause a big problem for collaboration as time passes. The hidden complexity interrupted the comprehension of the entire group's knowledge. He first addressed the hidden linked structure and then presented an automated navigation map to visualize the linked structure. The map is useful for helping learners to comprehend group knowledge [5]. However, mere visualization of the linked structure retained the limitation that learners could not figure out the collaborative status. In other words, they couldn't estimate whether they could proceed or not to the next learning activity in process-oriented collaborative learning.

In the next section we describe briefly the features of wiki for process-oriented collaborative learning. The visualization of group collaborative status is illustrated in Section 3, where we propose and discuss the new adaptive measures to visualize the status of group knowledge sharing. Finally we conclude in Section 4.

2 Collaborative Learning Based on Wiki

Collaborative learning environments provide an opportunity for a group's individuals to teach each other through knowledge sharing, and it is important to support an efficient group knowledge management system.

Wiki's group knowledge management is based on conversational knowledge sharing. It is background knowledge sharing will promote group collaborative learning effectively through inter-communication.

We will find the basic working structure of collaboration for visualization of group collaborative status.

2.1 Knowledge Sharing in Wiki-based Collaborative Learning

The main feature of wiki technology is freedom of creating and editing. Any users can create new contents and links and also can edit anything, although they are not author. As learners participate in creating and editing group pages, they can share their knowledge and experience. We would like to find any patterns of knowledge sharing for completed collaborative learning, because the visualization of patterns helps learners to decide on the starting point of the next learning exercise in time limited collaborative learning.

Then, what patterns are required for visualization? Both the foreign language translation and the relay novel projects of H. Kim *et al*. showed that we could recognize generalized patterns by the frequency of inter-communication [7]. When learners were translating the given paragraphs to be written in a foreign language, a change in modification frequency indicated a generalized pattern until the translation project was completed. When learners wrote a relay novel, the change in interactivity showed the same patterns. And then we should check the event type- creating, reading or editing- as well as the number of each event. The pattern seems to be impacted by the working structure for group collaboration.

2.2 Pre/Post Working Structure

Process-oriented collaborative learning should be followed by a working flow for effective learning in a given time limit. Furthermore, the previous process brings an impact to the current process and the current process will impact the next one. It is just like a domino effect. In process-oriented collaborative learning, the learning process flow is described in Figure 1.

In this structure, our basic working flow consists of the sharing and development processes for collaborative work. Sharing is pre-process and development is post-process. The prior knowledge should be shared first, because learners can reduce their differences in idea and ability for efficient collaboration by knowledge sharing. Through knowledge sharing, learners will achieve successful collaborative projects.

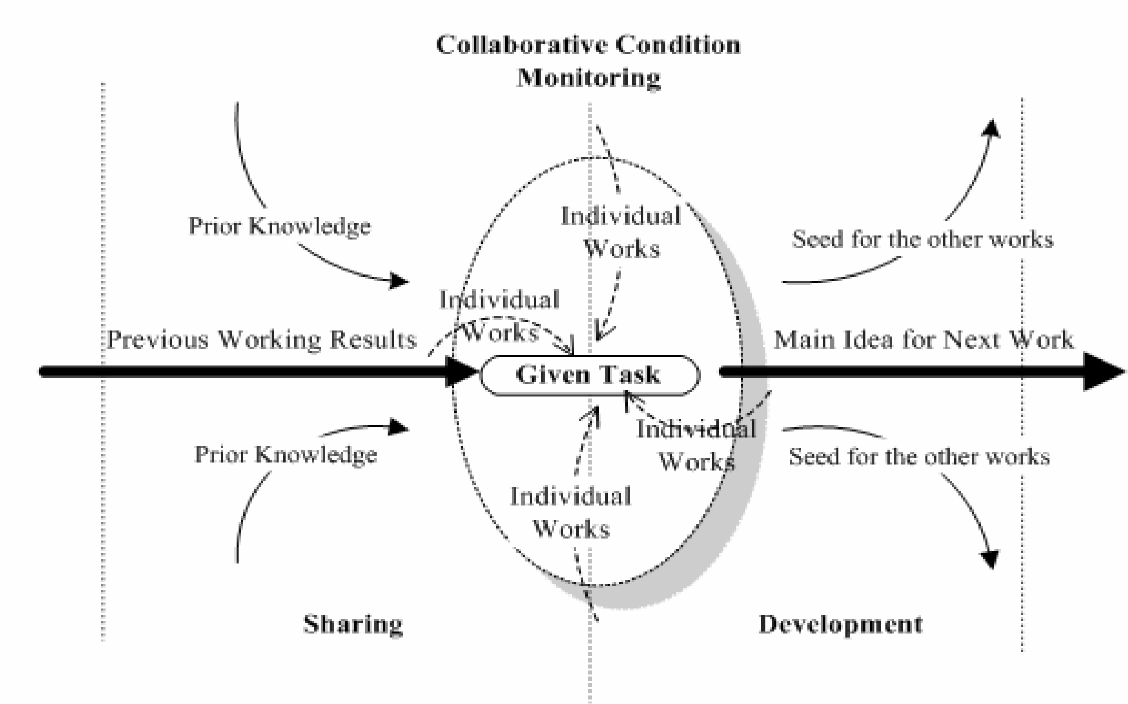

Fig.1. Pre/Post working structure

How can learners figure out the state of knowledge sharing in a group? We describe the method to estimate collaborative status to monitor the collaborative condition in the next section.

3 Visualization of Collaborative Status

A. Dieberger *et al*. showed the importance of a visualized interaction history for collaboration [2]. Through their access history, even lurkers contributed to an overall interaction history.

C. Bajaj *et al*. studied web-based collaborative visualization in a distributed simulation [1]. He presented an interactive model that provides users with an intuitive map of resources, users and tasks within the distributed environment. The visualization was expected to connect users with resources for active collaboration.

In this paper, we propose the adaptive measures to estimate how much the learners are sharing the group's contents.

3.1 Adaptive Measures for Visualization

We analyzed learners' work in the previous study's learner history DB [6]. We checked the event type, frequency and collaborative state. The results provide the solution to estimate the collaborative status. In the pattern we checked, group collaboration is improved by knowledge sharing and knowledge representation. Knowledge sharing means to read others' contents, and knowledge representation means to add new contents.

This study aims to develop measures which are able to present the collaborative status visually. The basic value is $Event_{(i)} \cdot \omega$. This is calculated by the event frequency ($Event_{(i)}$) and event type (ω) of learner *i* on a given page. The event type ω has a weight according to creating, reading or modifying the page. The $CoState_{(i)}$, the basic value for the collaborative status of learner *i*, is calculated using $State_{(i)}$ and $Event_{(i)} \cdot \omega$. If learner *i* has already read the given page after it's been modified, the $State_{(i)}$ value assigned is "1." If not, it is assigned "0". A higher $CoState_{(i)}$ value means a better collaborative status. The maximum of $CoState_{(i)}$ is 2(see equation 1).

$$CoState_{(i)} = State_{(i)} + \frac{Event_{(i)} \cdot \omega}{\sum_{i=1}^{n} \left(Event_{(i)} \cdot \omega\right)} \qquad (1)$$

According to equation 2, the value of $C_{(i)}$, which means learner *i*'s contribution in a group, can be calculated relatively by sum of the other learner's in *p* group pages.

$$C_{(i)} = \frac{\sum_{p=1}^{k} CoState_{(i)}}{\sum_{i=1}^{n} \sum_{p=1}^{k} CoState_{(i)}} \qquad (2)$$

The average score of $CoState_{(i)}$ can be used to present a representative value for the group's collaborative status $C_{(g)}$. We can monitor the group's collaborative condition using equation 3.

$$C_{(g)} = \frac{\sum_{i=1}^{n} \sum_{p=1}^{k} CoState_{(i)}}{N \cdot K} \qquad (3)$$

These measures always work adaptively, and it would be possible to monitor collaborative learning activities and participation.

3.2 Implementation and Analysis

We implemented the visualized interface of collaborative status according to the above measures in Figure 2. Both values of collaborative status and individual contribution were presented graphically by colored bar graphs.

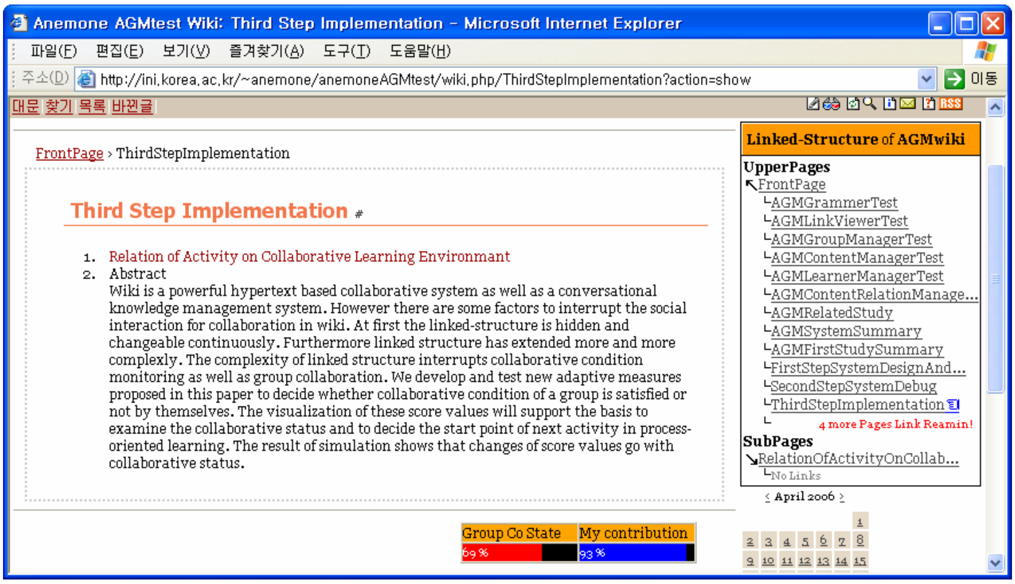

Fig.2. Implementation of interface

Table 1. The history of activity for simulation

Procedure	Event history (Stu1~Stu4)	$Event_{(stu1)} \cdot \omega$	$Event_{(stu2)} \cdot \omega$	$Event_{(stu3)} \cdot \omega$	$Event_{(stu4)} \cdot \omega$
Init..	(stu1) add 2 new pages	8	4	2	6
2	(stu1~4) read all pages	12	8	3	8
3	(stu2) modify 2 pages	12	16	5	11
4	(stu1~4) read modified pages	16	17	8	13
5	(stu4) add a new page	16	19	8	23
6	(stu2) modify 2 pages	18	25	10	24
7	(stu1~4) read all pages	22	29	13	26
8	(stu3) delete a page partially	34	34	20	31

The measures must be validated through a simulation as in Table 1. The events consisted of eight procedures which are common learning activities in wiki. Some events- the init, 3, 5 and 6 procedures in Table 1- were related to knowledge representation and others- the 2, 4, 7 and 8 procedures- were related to knowledge sharing. The values presented in Table 1 are the results of $Event_{(i)} \cdot \omega$ scores generated by four supposed learners.

According to the simulation we can see the desirable change that knowledge sharing improves the score value of $C_{(i)}$ and an individual's knowledge representation makes falling down the other's score in Figure 3. The knowledge representation is just a personal collaborative activity but becomes a new task to be shared by others. The value of $C_{(g)}$ then improves at the point where existing knowledge is shared by reading, and is reduced at the point where new knowledge is represented by a learner.

Furthermore, the value is improved more and more through a learner's collaborative activities. It is normal that the best collaboration requires the seamless collaborative activities of individuals. Through this simulation we can confirm the proposed measures' validity.

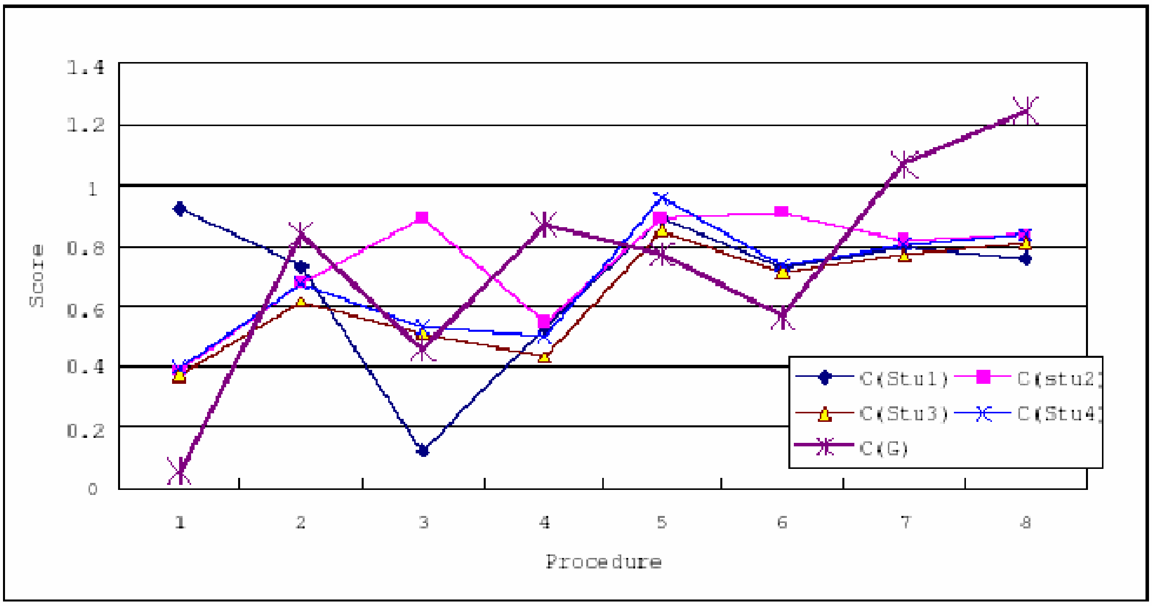

Fig.3. The change in score

4 Conclusion

Wiki is an excellent conversational knowledge management system in collaborative learning environments. Especially process-oriented learning requires knowledge sharing in each process [3]. In general collaborative learning, a pre-process is for individuals to share a prior knowledge of the main one. We divided these processes into pre and post structures.

Because the pre-process of collaboration is knowledge sharing, a group's individuals can figure out the status of the group's collaboration, and then they can proceed to the next process when enough knowledge sharing is achieved for learning in the group.

In this paper we propose adaptive measures for the visualization of collaborative status, and we show that a group's collaborative status can be visualized by the proposed measures using event knowledge sharing and representation. This visualization is expected to support a basis for not only efficient group collaboration but also the decision of learning progression in process-oriented learning

Continuously, we plan to study the adaptive learning progression model. We believe that there are some patterns for learning progression in collaborative learning.

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